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Practitioner's Docket No. U 012452-9

PATENT

**TRANSMITTAL LETTER TO THE U.S. DESIGNATED OFFICE (DO/US)--
ENTRY INTO THE U.S. NATIONAL STAGE UNDER CHAPTER I**

126
INTERNATIONAL APPLICATION NO. INTERNATIONAL FILING DATE PRIORITY DATE CLAIMED
PCT/SG98/00004 12 FEBRUARY 1999 —
TITLE OF INVENTION
METHOD AND APPARATUS FOR WATERMARKING WAVETABLE SYNTHESIS
ARCHITECTURES
APPLICANT(S)
1. CHANGSHENG XU
2. JIANKANG WU
3. QIBIN SUN

Box PCT

Assistant Commissioner for Patents

Washington D.C. 20231

ATTENTION: DO/US

NOTE: The completion of those filing requirements that can be made at a time later than 20 months from the priority date results from the Commissioner exercising his judgment under the authority granted under 35 U.S.C. 371(d). The filing receipt will show the actual date of receipt of the last item completing the entry into the national phase. See 37 C.F.R. 1.491, which states: "An international application enters the national stage when the applicant has filed the documents and fees required by 35 U.S.C. 371(c) within the periods set forth in § 1.494 and § 1.495."

WARNING: Where the items are those that can be submitted to complete the entry of the international application into the national phase subsequent to 20 months from the priority date, the application is still considered to be in the international stage. And if mailing procedures are utilized to obtain a date the express mail procedure of 37 C.F.R. 1.10 must be used (because international application papers are not covered by an ordinary certificate of mailing. 37 C.F.R. 1.8(2)(xi)).

NOTE: Documents and fees must be clearly identified as a submission to enter the national stage under 35 U.S.C. 371, otherwise the submission will be considered as being made under 35 U.S.C. 111. 37 C.F.R. 1.494(f).

1. Applicant herewith submits to the United States Designated Office (DO/US) the following items

CERTIFICATION UNDER 37 C.F.R. 1.10*

(Express Mail label number is **mandatory**.)

(Express Mail certification is optional.)

I hereby certify that this paper, along with any document referred to, is being deposited with the United States Postal Service on this date DECEMBER 2, 1999, in an envelope as Express Mail Post Office to Addressee, mailing Label Number EL386266227US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

GERALDINE MARTI

(type or print name of person mailing paper)

Geraldine Marti

Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

***WARNING:** Each paper or fee filed by "Express Mail" must have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b).

"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

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EL386266227US

under 35 U.S.C. 371:

- a. ☒ This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).
- b. ☒ The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 C.F.R. 1.492), as indicated below:

2. Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
*	TOTAL CLAIMS	68 --20=	48	x\$ 18.00=	\$ 864.00 (NOT PAID AT THIS TIME)
	INDEPENDENT CLAIMS	8 --3=	5	x\$ 78.00=	\$ 390.00 (NOT PAID AT THIS TIME)
	MULTIPLE DEPENDENT CLAIMS(S) (if applicable) + \$260.00				
BASIC FEE**	The international search fee, as set forth in § 1.445(a)(2) to be paid to the US PTO acting as an international Searching Authority: <input type="checkbox"/> has been paid (37 CFR 1.492(a)(2)).....\$760.00 <input checked="" type="checkbox"/> has not been paid (37 CFR 1.492(a)(3)).....\$970.00 <input type="checkbox"/> where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5))..... \$840.00				
	Total of above Calculations				970
SMALL ENTITY	Reduction by ½ for filing by small entity, if applicable. Affidavit must be filed also. (note 37 CFR 1.9, 1.27, 1.28)				-
	Subtotal				970.00
	Total National Fee				970.00
	Fee for recording the enclosed assignment document \$40.00 (37 CFR 1.21(h)). (See Item 10 below). See attached "ASSIGNMENT COVER SHEET (37 CFR 3.34)".				
TOTAL	Total Fees enclosed				970.00

*See attached Preliminary Amendment Reducing the Number of Claims.

****WARNING:** "To avoid abandonment of the application, the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 20 months from the priority date; *** (2) the basic national fee (see § 1.492(a)). The 20-month time limit may not be extended." 37 C.F.R. § 1.494(b).

(Transmittal Letter to the United States Designated Office (DO/US - Entry into National Stage under 35 USC 371--page 2 of 7) 13-6

- i. ☒ [X] A check in the amount of \$ 970.00 to cover the above fees is enclosed.
ii. ☐ [] Please charge Account No. _____ in the amount of \$ _____.

A duplicate copy of this sheet is enclosed.

WARNING:

If the translations of the international application, oath or declaration and national fee have not been submitted by the applicant within twenty (20) months from the priority date, the applicant will be so notified and given a period of time within which to file the translation and/or oath or declaration in order to prevent abandonment. The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than twenty (20) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than twenty (20) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1.136 will apply. 37 CAR § 1.494(c); Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35.

3. A copy of the International application as filed (35 U.S.C. 371(c)(2)):
- a. ☐ [] is transmitted herewith.
b. ☐ [] is not required, as the application was filed with the United States Receiving Office.
c. ☒ [X] has been transmitted
- i. ☒ [X] by the International Bureau. Date of mailing of the application from form PCT/IB/308): _____.
ii. ☐ [] by applicant on _____
Date

NOTE: *Section 1.494(b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 20 months from the priority date to avoid abandonment. "The International Bureau nominally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies the applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage and applicant has received notice from the International Bureau, applicant need only pay the basic national fee by 20 months from the priority date." [This can now be paid subsequently with a surcharge.] Notice of Jan. 7, 1993, 1147 O.G. 29 to 40, at 35.*

4. A translation of the International application into the English language (35 U.S.C. 371(c)(2)):
- a. ☒ [X] is transmitted herewith.
b. ☐ [] is not required as the application was filed in English.
c. ☐ [] was previously transmitted by applicant on _____
Date

5. ☒ Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. 371(c)(3)):

NOTE: The Notice of January 7, 1993 indicates that 37 C.F.R. § 1.494(d) was "amended to clarify the existing practice that PCT Article 19 Amendments must be submitted by 20 months from the priority date, which time may not be extended." This Notice further advises: "Of course, the failure to do so does not result in loss of the subject matter of PCT Article 19 amendments. The applicant may submit that subject matter in a preliminary amendment filed under Section 1.121. In many cases, filing an amendment under Section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 35. See item 11(c) below.

- a. ☐ are transmitted herewith.
- b. ☐ have been transmitted
- i. ☐ by the International Bureau. Date of mailing of the amendment (from form PCT/IB/308): _____.
- ii. ☐ by applicant on _____.
- Date
- c. ☒ have not been transmitted, as
- i. ☐ no notification has been received that the International Search Authority has received the Search Copy.
- ii. ☐ the Search Copy was received by the International Searching Authority, but the Search Report has not yet been issued. Date of receipt of Search Copy from form PCT/ISA/202): _____.
- iii. ☒ applicant chose not to make amendments under PCT Article 19. Date of mailing of Search Report (from form PCT/ISA/210): _____.
- iv. ☐ the time limit for the submission of amendments has not yet expired. The amendments, or a statement that amendments have not been made, will be transmitted before the expiration of the time limit under PCT Rule 46.1.
6. ☒ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)):
- a. ☐ is transmitted herewith.
- b. ☐ is not required as the amendments were made in the English language.
- c. ☒ has not been transmitted for reasons indicated at point 5(c) above.
7. ☒ An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115
- a. ☐ was previously submitted by applicant on _____.
- Date
- b. ☒ is submitted herewith, and such oath or declaration
- i. ☐ is attached to the application.
- ii. ☒ identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or (c) and 5(b); and states that they were reviewed by the inventor, as required by 37 C.F.R. 1.70.
- iii. ☐ will follow.

II. Other document(s) or information included:

8. ☒ An international Search Report or Declaration under PCT Article 17(2)(a):
- ☐ is transmitted herewith.
 - ☐ has been transmitted by the International Bureau. Date of mailing from form PCT/IB/308): _____.
 - ☐ is not required, as the application was searched by the United States International Searching Authority.
 - ☒ will be transmitted promptly upon request.
 - ☐ has been submitted by applicant on _____ Date
 - ☐ is not transmitted, as the international search has not yet issued.
9. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98:
- ☐ is transmitted herewith.
Also transmitted herewith is (are)
☐ Form PTO-1449 (PTO/SB/08A and 08B)
☐ Copies of citations listed
 - ☒ will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. 371(c).
 - ☐ was previously submitted by applicant on _____ Date
10. ☒ An assignment document is transmitted herewith for recording. A separate
- ☐ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or
- ☐ FORM PTO—1595
is also attached.
- ☒ Please mail the recorded assignment document to:
- ☒ the person whose signature and address appears below.
 - ☐ the following:
11. ☒ Additional documents
- ☒ Copy of request (PCT/RO/101)
 - ☐ International Publication No. _____
 - ☐ Specification, claims and drawing
 - ☐ Front page only
 - ☒ Preliminary amendment (37 C.F.R. § 1.121)
 - ☒ Other FORM PCT/RO/105
12. ☒ The above checked items are being transmitted
- ☒ before the 18th month publication.
 - ☐ after publication and the article 20 communication, but before 20 months from the priority date.
 - ☐ after 20 months (revival).

NOTE: *Petition to revive (37 C.F.R. 1.137(a) or (b)) is necessary if 35 U.S.C. 371 requirements are submitted after 20 months.*

13. ☐ Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on _____ namely:
Date

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: *"A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 CFR 1.136(a)(3).*

NOTE: *"Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 CFR 1.26(a).*

☒ The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 12-0425.

☒ 37 C.F.R. 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 20 months without extension (37 C.F.R. § 1.494(b)(2)), results in abandonment of the application, it would be best to always check the above box.*

☐ 37 C.F.R. 1.492(b), (c), and (d) (presentation of extra claims)

NOTE: *Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment, prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.*

☒ 37 C.F.R. 1.17 (application processing fees)

☐ 37 CFR 1.17(a)(1)-(5)(extension fees pursuant to § 1.136(a).

☒ 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b)).

NOTE: *Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. 1.311(b).*

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying or at the time of paying . . . issue fee...." From the wording of 37 C.F.R. 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

[X] 37 C.F.R. 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 20 months after the priority date.

Reg. No. 25,858

Tel. No.: (212)708-1930

Customer No.:


SIGNATURE OF PRACTITIONER

WILLIAM R. EVANS

(type or print name of practitioner)

LADAS & PARRY

P.O. Address

26 WEST 61ST STREET
NEW YORK, NEW YORK 10023

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application: CHANGSHENG XU, et al

International Application No.: PCT/SG99/00004

International Filing Date: 12 FEBRUARY 1999

Priority Date: --

For: METHOD AND APPARATUS FOR WATERMARKING WAVETABLE
SYNTHESIS ARCHITECTURES

Attorney Docket No.: U 012452-9

**Assistant Commissioner for Patents
Washington, D.C. 20231**

Sir:

PRELIMINARY AMENDMENT

Please amend the above application as follows:

IN THE CLAIMS

Claim 6, line 1, delete "or 5"

Claim 9, line 1, delete "or 8"

CERTIFICATE UNDER 37 1.10

I hereby certify that this paper is being deposited with the United States Postal Service on this date DECEMBER 2, 1999 in an envelope as "EXPRESS MAIL POST OFFICE TO ADDRESSEE" Mailing Label Number EL386266227US addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231

GERALDINE MARTI

(Type or print name of person mailing paper)

Geraldine Marti

(Signature of person mailing paper)

NOTE: Each paper or fee referred to as enclosed herein has the number of the "EXPRESS MAIL" mailing label place thereon prior to mailing 37 CFR 1.16(b).

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Claim 10, line 1, delete "or 5"

Claim 11, line 1, delete "any one of claims 1 to 10" and replace therefor

-- claim 1--

Claim 12, line 1, delete "any one of claims 1 to 11" and replace therefor

-- claim 1--

Claim 13, line 1, delete "any one of claims 1 to 12" and replace therefor

-- claim 1--

Claim 14, line 1, delete "any one of claims 1 to 13" and replace therefor

-- claim 1--

Claim 20, line 1, delete "or 19"

Claim 23, line 1, delete "or 22"

Claim 24, line 1, delete "or 19"

Claim 25, line 1, delete "any one of claims 15 to 24" and replace therefor

-- claim 15--

Claim 26, line 1, delete "any one of claims 15 to 25" and replace therefor

-- claim 15--

Claim 27, line 1, delete "any one of claims 15 to 26" and replace therefor

-- claim 15--

Claim 28, line 1, delete "any one of claims 15 to 27" and replace therefor

-- claim 15--

Claim 34, line 1, delete "or 33"

Claim 37, line 1, delete "or 36"

Claim 38, line 1, delete "or 33"

Claim 39, lines 1-2, delete "any one of claims 29 to 38" and replace therefor

-- claim 29--

Claim 40, lines 1-2, delete "any one of claims 29 to 39" and replace therefor

-- claim 29--

Claim 41, lines 1-2, delete "any one of claims 29 to 40" and replace therefor

-- claim 29--

Claim 42, lines 1-2, delete "any one of claims 29 to 41" and replace therefor

-- claim 29--

Claim 45, line 1, delete "or 44"

Claim 47, line 1, delete "or 46"

Claim 48, line 1, delete "any one of claims 43 to 47" and replace therefor

-- claim 43--

Claim 49, line 1, delete "any one of claims 43 to 48" and replace therefor

-- claim 43--

Claim 50, line 1, delete "any one of claims 43 to 49" and replace therefor

-- claim 43--

Claim 53, line 1, delete "or 52"

Claim 55, line 1, delete "or 54"

Claim 56, line 1, delete "any one of claims 51 to 55" and replace therefor

-- claim 51--

Claim 57, line 1, delete "any one of claims 51 to 56" and replace therefor

-- claim 51--

Claim 58, line 1, delete "any one of claims 51 to 57" and replace therefor

-- claim 51--

Claim 61, line 1, delete "or 60"

Claim 63, line 1, delete "or 62"

Claim 64, lines 1-2, delete "any one of claims 59 to 63" and replace therefor

-- claim 59--

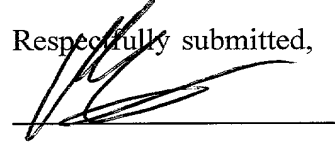
Claim 65, lines 1-2, delete "any one of claims 59 to 64" and replace therefor

-- claim 59--

Claim 66, lines 1-2, delete "any one of claims 59 to 64" and replace therefor

-- claim 59--

Respectfully submitted,



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Method and Apparatus for Watermarking Wavetable Synthesis Architectures**FIELD OF THE INVENTION**

The present invention relates to the field of digital audio signal processing, and in particular to systems for watermarking digital audio signals.

BACKGROUND

The rapid development of computer networks and the increased use of multimedia data via the Internet have resulted in the exchange of digital information becoming faster and more convenient. However, the open environment of the Internet creates consequential problems regarding copyright of artistic works, and in particular the unlawful distribution of digital multimedia works without authorisation of the owners. To dissuade and perhaps eliminate illegal copying, a need exists for strengthening and assisting in the enforcement of copyright protection of such works.

Digital watermarking is a technique that has been applied to address this problem in respect of multimedia data, including audio, image and video data. Watermarking directly embeds copyright information into the original media and seeks to maintain the presence of the information in the media, even after manipulations are applied to the watermarked data. With respect to digital audio data, a watermark should be inaudible and robust against different attacks and collusion to defeat the watermarking. Furthermore, watermark detection should unambiguously identify the ownership and copyright. Still further, digital-watermarking technology is considered to be an integral part of several contributions to international standards, such as JPEG 2000 and MPEG 4.

Typically, watermarking is applied directly to data samples themselves, whether this be still image data, video frames or audio segments. However, such systems fail to address the issue of audio coding systems, where digital audio data is not available, but a form of representing the audio data for later reproduction according to a protocol is. It is well-known that tracks of digital audio data can require large amounts of storage and high data transfer rates, whereas synthesis-architecture coding protocols

such as the Musical Instrument Digital Interface (MIDI) have corresponding requirements that are several orders of magnitude lower for the same audio data. MIDI audio files are not files made entirely of sampled audio data (i.e., actual audio sounds), but instead contain synthesiser instructions, or MIDI messages, to reproduce
5 the audio data. The synthesiser instructions contain much smaller amounts of sampled audio data. That is, a synthesiser generates actual sounds from the instructions in a MIDI audio file. Fig. 7 is a block diagram of an example of a MIDI system 700 based on a personal computer 710. The computer 710 has a MIDI interface that can provide MIDI output 740 to a synthesiser 720. Alternatively, the
10 synthesis may be performed using a sound card (not shown) installed in the computer 740, which may have a MIDI interface. In response to the MIDI instructions 740, the synthesiser produces audio output that can be provided to speakers 730, for example.

Expanding upon MIDI, Downloadable Sound (DLS) is a synthesiser-architecture
15 specification that requires a hardware or software synthesiser to support its components. DLS permits additional instruments to be defined and downloaded to a synthesiser besides the standard 128 instruments provided by the MIDI system. The DLS file format stores both samples of digital sound data and articulation parameters to create at least one sound instrument. The articulation parameters include
20 information about envelopes and loop points. For further information, reference is made to "Downloadable Sounds Level 1, Version 1.0", The MIDI Manufacturers Association, CA, USA, 1997. Downloadable Sound is expected to become a new standard in the musical industry, because of its specific advantages. On the one hand, when compared with MIDI, DLS provides a common playback experience and an
25 unlimited sound palette for both instruments and sound effects. On the other hand, when compared with sampled digital audio, it has true audio interactivity and, as noted hereinbefore, smaller storage requirements.

In this connection, when compared with digital video and image watermarking
30 techniques, digital audio watermarking techniques provide a special challenge because the human auditory system (HAS) is much more sensitive than the human visual system (HVS). An ideal watermark is inaudible and robust. By inaudibility is

meant that watermark makes no difference in relation to the digital audio signal in listening tests. By robustness is meant that the watermark is difficult, and ideally impossible, to remove without destroying the host audio signal. There is, however, always a conflict between inaudibility on the one hand and robustness on the other in
5 existing audio watermarking techniques. This is further complicated by the special circumstances created by WT audio formats such as DLS, which are not complete digital audio samples, but instead contain instructions to create audio data.

Thus, a need clearly exists for improved watermark embedding and extracting
10 systems for WT audio formats like DLS, which also effectively address the conflict between inaudibility and robustness of watermarks.

SUMMARY

In accordance with a first aspect of the invention, there is disclosed a method of
15 embedding a digital watermark in digital audio data coded using a synthesiser-architecture format. The method includes the step of: embedding at least a portion of the digital watermark in sample data and articulation parameters of the synthesiser-architecture format.

20 Preferably, the method includes the step of adaptively coding the digital watermark in the sample data. Preferably, redundancy adaptive coding is used based on a finite automaton.

Preferably, the method includes the step of hiding the digital watermark in the
25 articulation parameters by creating virtual parameters. It may also include the step of embedding the digital watermark in the WT virtual parameters. Still further, the method may include the step of extracting one or more coded bits from watermarked sample data, the virtual instrument created dependent upon a watermarked coded bit sequence. The method may also include the step of hiding the watermarked coded bit
30 sequence in the articulation parameters. More preferably, it includes the step of embedding the watermarked coded bit sequence in the virtual parameters. The digital

watermarked coded bit sequence and/or the digital watermark may be encrypted as well.

- 5 Preferably, the method includes step of generating the digital watermark. It may also include the step of dividing the digital audio data coded using a synthesiser-architecture format into the sample data and the articulation parameters.

Optionally, the method may include the step of embedding a playback-control signal.

- 10 Preferably, the digital audio data coded using a synthesiser-architecture format is wavetable (WT) audio, and more preferably a downloadable sound (DLS).

- 15 In accordance with a second aspect of the invention, there is disclosed an apparatus for embedding a digital watermark in digital audio data coded using a synthesiser-architecture format. The apparatus includes: a device for embedding at least a portion of the digital watermark in sample data of the synthesiser-architecture format; and a device for embedding at least a portion of the digital watermark in articulation parameters of the synthesiser-architecture format.

- 20 In accordance with a third aspect of the invention, there is disclosed a computer program product having a computer readable medium having a computer program recorded therein for embedding a digital watermark in digital audio data coded using a synthesiser-architecture format. The computer program product includes: a module for embedding at least a portion of the digital watermark in sample data of the
25 synthesiser-architecture format; and a module for embedding at least a portion of the digital watermark in articulation parameters of the synthesiser-architecture format.

- 30 In accordance with a fourth aspect of the invention, there is disclosed a method of extracting a digital watermark from watermarked digital audio data coded using a synthesiser-architecture format. The method includes the steps of: detecting a watermark from articulation parameters of the watermarked digital audio data coded using a synthesiser-architecture format; detecting a watermark from sample data of

the watermarked digital audio data coded using a synthesiser-architecture format; and verifying the watermark by comparing the detected watermarks.

5 Preferably, the method includes the step of replacing the watermark from the sample data with a corresponding watermark embedded in the articulation parameters if the watermark from the sample data is not available or has been modified. The watermark from the sample data preferably includes an adaptively coded bit sequence. The method may include the step of decrypting the adaptively coded bit sequence and/or the digital watermark.

10 Preferably, the method includes the step of dividing the watermarked digital audio data coded using a synthesiser-architecture format into the sample data and the articulation parameters.

15 Optionally, the method includes the step of extracting a playback-control signal.

More preferably, the digital audio data coded using a synthesiser-architecture format is wavetable (WT) audio and more preferably, a downloadable sound (DLS).

20 In accordance with a fifth aspect of the invention, there is disclosed an apparatus for extracting a digital watermark from watermarked digital audio data coded using a synthesiser-architecture format. The apparatus includes: a device for detecting a watermark from articulation parameters of the watermarked digital audio data coded using a synthesiser-architecture format; a device for detecting a watermark from
25 sample data of the watermarked digital audio data coded using a synthesiser-architecture format; and a device for verifying the watermark by comparing the detected watermarks.

In accordance with a sixth aspect of the invention, there is disclosed a computer
30 program product for extracting a digital watermark from watermarked digital audio data coded using a synthesiser-architecture format. The computer program product includes: a module for detecting a watermark from articulation parameters of the

watermarked digital audio data coded using a synthesiser-architecture format; a module for detecting a watermark from sample data of the watermarked digital audio data coded using a synthesiser-architecture format; and a module for verifying the watermark by comparing the detected watermarks.

5

In accordance with a seventh aspect of the invention, there is disclosed a system for watermarking a wavetable (WT) audio file, and more particularly a DLS file. The system includes: a module for embedding watermark data into a WT file; and a module for extracting the watermark data from the embedded WT file

10

In accordance with an eighth aspect of the invention, there is disclosed a method of playing a watermarked WT file having a control signal embedded therein to control the number of playbacks. The method includes the steps of: automatically checking the watermarked WT signal for the control signal to ensure authentication; if the control signal indicates at least one playback remains, playing the watermarked WT file; and decrementing the control signal.

15

BRIEF DESCRIPTION OF THE DRAWINGS

A small number of embodiments of the invention are described hereinafter with reference to the drawings, in which:

20

Fig. 1 is a block diagram of a system for embedding digital audio watermarks in wavetable audio (WT) in accordance with a first embodiment of the invention;

Fig. 2 is a detailed block diagram of an adaptive-bit coding module 130 implemented in the watermark embedding system of Fig. 1;

25

Fig. 3 is a state diagram of a finite automaton module 220 implemented in the adaptive-bit coding module 220 of Fig. 2;

Fig. 4 is a detailed block diagram of a parameters hiding module 140 implemented in the watermark embedding system of Fig. 1;

30

Fig. 5 is a block diagram of a system for extracting digital audio watermarks from watermarked WT audio in accordance with a second embodiment of the invention;

Fig. 6 is a block diagram of an example of a computer system, with which the embodiments can be practised; and

Fig. 7 is a block diagram of a conventional MIDI system based on a personal computer.

DETAILED DESCRIPTION

- 5 A method, an apparatus, and a computer program product for digital audio watermarking of wavetable (WT) format audio, including downloadable sounds, are described hereinafter. Correspondingly, a method, an apparatus, and a computer program product for extracting digital audio watermarks from watermarked WT format audio are also described. In the following description, numerous specific
- 10 details are set forth including content addressing techniques. It will be apparent to one skilled in the art, however, that the present invention may be practised without these specific details. In other instances, well-known features are not described in detail so as not to obscure the present invention.
- 15 The watermark embedding and extracting systems according to the embodiments of the invention are advantageous in that a watermark is inaudible within its host signal and difficult or impossible to remove by unauthorised access. Further, the watermark can be easily extracted by an authorised person such as the owner of the copyright in the audio work, and it is robust against incidental and intentional distortions.
- 20 In the following description, components of the system are described as modules. A module, and in particular its functionality, can be implemented in either hardware or software. In the software sense, a module is a process, program, or portion thereof, that usually performs a particular function or related functions. In the hardware sense,
- 25 a module is a functional hardware unit designed for use with other components or modules. For example, a module may be implemented using discrete electronic components, or it can form a portion of an entire electronic circuit such as an Application Specific Integrated Circuit (ASIC). Numerous other possibilities exist. Those skilled in the art will appreciate that the system can also be implemented as a
- 30 combination of hardware and software modules.

System for Embedding Watermarks in WT Audio

Fig. 1 is a block diagram of a system for embedding a watermark 126 in an original WT audio file 110. Again, a WT audio file contains two parts: articulation parameters and sample data, or only contains articulation parameters such as MIDI. Unlike
5 traditional sampled digital audio, the sample data in a WT audio file are not the prevalent components. To the contrary, the WT articulation parameters control how sounds are played or reproduced.

An original WT audio 110 is input to a content-extracting module 120, which
10 produces articulation parameters 122 and sample data 124 as its output. That is, the original WT audio 110 is divided into sample-data and articulation-parameter components 124 and 122. The articulation parameters 122 are input to a parameters hiding module 140, and the sample data 124 are input to an adaptive-bit coding
15 module 130. A watermark 126 is also input to both the parameters hiding and adaptive-bit coding modules 140, 130. Thus, not only is a watermark 126 embedded into the sample data 124, but it is also embedded into the articulation parameters 122. Two different embedding modules 130, 140 process them 122, 124, respectively, and form relevant watermarked outputs 142, 132.

20 The adaptive-bit coding module 130 is based on a finite automaton and is depicted in greater detail in Fig. 2. The adaptive-bit coding module 130 produces watermarked sample data 132 at its output. Basically, this module 130 embeds the watermark 126 into the audio sample data 124 by replacing bits of the sample points with bits of a binary sequence of the watermark 126. This is described in greater detail
25 hereinafter with reference to Figs. 2 and 3.

The watermarked sample data 132 is provided as input to both a coding-bit extracting module 150 and an integrating module 160. This module 150 extracts the coded-bit
30 extracting module 150 is input to the parameters-hiding module 140, as well. As described hereinafter in greater detail with reference to Fig. 4, the parameters-hiding module 140 embeds the watermark 126, and if necessary the watermarked coded-bit

sequence of the watermarked sample data 132, into the articulation parameters 122.

The watermarked articulation parameters 142 are input to the integrating module 160, along with the watermarked sample data 132. The integrating module 160 produces a watermarked WT audio 162 as the output of the embedding system 100 by integrating
5 the watermarked sample data 132 and the articulation parameters 142. The integrating module 160 repackages the watermarked articulation parameters 142 and watermarked sample data 132 in standard WT audio form.

Adaptive-Bit Coding Module 200

- 10 Fig. 2 is a block diagram illustrating in greater detail the adaptive-bit coding module 200 (i.e., 130 in Fig. 1). Bits of the sample data are also coded according to the HAS, so as to ensure minimal distortion of original sample data. The watermark 212 is processed as a string of binary sequences. Each bit of the sequence 212 replaces a corresponding bit of the sample points 210. The particular location in the sample
15 point is determined by the finite automation (FA) module 220 and the HAS. The locations are determined by the sample locating module 230. The number of sample points is determined by the redundancy adaptive coding module 240, dependent on the HAS 250.
- 20 As shown in Fig. 2, the output of the finite automaton module 220 and a sample frame 210 (124) of WT audio data are input to the sample-locating module 230. The output of the sample-locating module 230 is input to a redundancy adaptive coding module 240, which also receives input based on the HAS 250. The redundancy adaptive coding module 240 produces the watermarked sample frame 242 as the output of the
25 adaptive coding module 200 (130).

Adaptive-bit coding has, however, low immunity to manipulations. Embedded information can be destroyed by channel noise, re-sampling, and other operations.

- Adaptive-bit coding technique is used based on several considerations. Firstly, unlike
30 sampled digital audio, WT audio is a parameterised digital audio, so it is difficult to attack using typical signal processing techniques, such as adding noise and re-sampling. Secondly, the size of a wave sample 210 in WT audio is small, and

therefore it is unsuitable to embed a watermark in the sample in the frequency domain. Thirdly, to ensure robustness, the watermarked bit sequence of sample data is embedded into the articulation parameters 122 of WT audio. If the sample data are distorted, the embedded information can be used to restore the coded bits of the sample data 124.

The operation or functionality of a finite automaton M implemented by the module 220 can be described as a quintuple:

$$M = \langle X, Y, S, \delta, \lambda \rangle, \quad (1)$$

where X is a non-empty finite set (the input alphabet of M), Y is a non-empty finite set (the output alphabet of M), S is a non-empty finite set (the state alphabet of M), $\delta: S \times X \rightarrow S$ is a single-valued mapping (the next state function of M) and $\lambda: S \times X \rightarrow S$ is a single-valued mapping (the output function of M).

The elements X, Y, S, δ , and λ are expressed as follows:

$$X = \{0, 1\}, \quad (2)$$

$$Y = \{y_1, y_2, y_3, y_4\}, \quad (3)$$

$$S = \{S_0, S_1, S_2, S_3, S_4\}, \quad (4)$$

$$S_{i+1} = \delta \{S_i, x\}, \text{ and} \quad (5)$$

$$y_i = \lambda \{S_i, x\}, \quad (6)$$

where y_i ($i = 1, 2, 3, 4$) is the number of sample points that are jumped off when embedding bit corresponding to relevant states, x is the element of X and has a value of 0 or 1, S_i ($i = 0 - 4$) is five types of states corresponding to 0, 00, 01, 10 and 11, respectively, and S_0 is the initial state.

25

The state transfer diagram 300 of the finite automaton of the module 220 is depicted in Fig. 3. Each state transition is indicated with a single-headed arrow with an input extending from the current state to the next state. The initial state S_0 310 makes a transition to either state S_1 320 for input 00 or to state S_2 330 for 01. The state S_1 320 makes a transition to itself for 00 or to state S_2 330 for 01. The state S_2 320 makes a transition to state S_3 340 for 10 or to state S_4 350 for 11. The state S_3 340 makes a

30

transition to state S_2 330 for 01 or to state S_1 320 for 00. The state S_4 350 makes a transition to itself for 11 or to state S_3 340 for 10.

Appendix A contains an example of adaptive coding using low-bit data hiding to
5 embed a watermark into WT sample data.

Parameters-Hiding Module 400

Fig. 4 is a block diagram illustrating in greater detail the parameters-hiding module
400 (i.e., 140 of Fig. 1). In particular, to ensure the robustness of the watermarked
10 WT audio 162, the parameters-hiding module 400 embeds the watermark 412 (126),
and if necessary the watermarked bit sequence 410, into the WT articulation
parameters (414, 122). The watermark 412 and watermarked bit sequence 410 are
input to an encrypting module 420, which encrypts them and forms a data stream.
Preferably, DES encryption is implemented by the module 420. However, numerous
15 other encryption techniques, including Advanced Encryption Standard (AES) such as
LOK197, Twofish and Serpent, can be practised instead without departing from the
scope and spirit of the invention.

The WT articulation parameters 414 are input to a module 430 for generating WT
20 virtual parameters. The virtual parameters are used to embed the watermarked data
stream into the WT articulation parameters. The virtual parameters are generated by
the module 430 from the WT articulation parameters 414. The output module 430 is
provided to a module 440 for embedding the watermark into the articulation
parameters 414 to produce watermarked articulation parameters 442 dependent on the
25 watermarked coded bit sequence 410 and the watermark 412, which are preferably
encrypted by encrypting module 420 before being input to the module 440. Because
attackers do not know the location of the virtual parameters, the embedded data are
difficult to detect and remove in the presence of attacks. On the other hand,
embedding both the watermark 412 and the watermarked bit sequence 410 into the
30 articulation parameters 414 ensures the correction of detected distortions of
watermarks in the WT sample data 124.

Appendix B contains an example of parameters hiding by generating virtual parameters.

5 The watermark embedding system 100 of Figs. 1 to 4 advantageously provides a watermark that is inaudible within its host WT signal and difficult or impossible to remove by unauthorised access. Further, an authorised person can easily extract the watermark. Still further, it is robust against incidental and intentional distortions.

System for Extracting Watermarks from Watermarked WT

10 Fig. 5 is a block diagram of a corresponding system 500 for extracting a watermark 500 from watermarked WT audio 510 in accordance with a second embodiment. This system 500 performs substantially the inverse operation of the embedding system 100. In the extraction process implemented by the system 500, the original WT audio is not needed.

15 The watermarked WT audio 510 is input to a content-extracting module 520, which produces watermarked articulation parameters 522 and watermarked sample data 524 as its output. This module 520 implements the inverse operations of the integrating module 160. That is, the watermarked WT audio 510 is divided into its component
20 parts, sample data 524 and articulation parameters 522. The watermarked sample data 524 are provided to a coding-bit detecting module 540, and the watermarked articulation parameters 522 are provided to a module for detecting embedded information 530. The detecting module 530 produces watermarked coded bit information 532 and watermark information 542 at its output to the coding-bit
25 detecting and verifying modules 540 and 550, respectively. The detecting module 530 performs the inverse operations of the parameters-hiding module 140. It finds the virtual parameters, decrypts the virtual parameters and extracts the watermark and watermarked coded bits of WT sample data. The code-bit detecting module 540 performs the inverse operations of module 130. It locates the positions of coding bits
30 based on the finite automaton, determines the value of the bits corresponding to binary watermark sequence based on the redundancy technique and the HAS, and recovers the watermark.

The encrypted watermark information in the virtual parameters of the articulation parameters is detected, as is the watermark sequence in the coding-bits of the sample data. The coding-bit detecting module detects the coding-bits of the watermarked sample data 524, if available, which is provided as input to the verifying module 550
5 as well. The verifying module 550 compares the watermark sequence in the sample data 524 with the watermark information 542 in the articulation parameters to verify the watermark. If the watermarked sample data 524 has suffered distortions and the watermark sequence cannot be detected by the module 540, the watermarked coding-bit sequence 532 is used to restore the coding-bit information in the sample data 524
10 and make the detection in the restored data. Similarly, the verifying module 552 verifies the detected watermark by comparing the output of the module 540 with the information 542 embedded in the articulation parameters 522.

Authorisation of Playback

15 Optionally, the embedding system 100 embeds an information flag to control the number of times that an authorised user can playback the WT audio. That is, for an authorised user, the WT audio can be played a fixed number of times determined by the WT audio owner. Detection of the number of repeat times is built into the play tools. When the WT audio is about to be played, the control information is first
20 detected. After each use, the remaining number of times to be played decrements. If it reaches to zero, the particular WT audio cannot be played back. Embedding and detecting the control information is carried out by the same modules used to embed and detect watermarks in the articulation parameters, i.e. another virtual instrument is generated for the control signal.

25 The foregoing embodiments of the invention are advantageous in that watermark information can be inaudibly embedded in WT audio and robustly detected and extracted. Preferably, the embodiments of the invention can be implemented using a computer system, such as the general-purpose computer shown in Fig. 6. In
30 particular, the systems of Figs. 1 and 5 can be implemented as software, or a computer program, executing on the computer. The method or process steps for embedding and extracting watermarks to and from a WT audio are effected by instructions in the

software that are carried out by the computer. Again, the software may be implemented as one or more modules for implementing the process steps. That is, a module is a part of a computer program that usually performs a particular function or related functions.

5

In particular, the software may be stored in a computer readable medium, including the storage devices described hereinafter. The software is loaded into the computer from the computer readable medium and then the computer carries out its operations. A computer program product includes a computer readable medium having such
10 software or a computer program recorded on it that can be carried out by a computer. The use of the computer program product in the computer preferably effects advantageous apparatuses for embedding and extracting watermarks to and from a WT audio in accordance with the embodiments of the invention.

15 The computer system 600 includes the computer 602, a video display 616, and input devices 618, 620. In addition, the computer system 600 can have any of a number of other output devices including line printers, laser printers, plotters, and other reproduction devices connected to the computer 602. The computer system 600 can be connected to one or more other computers via a communication interface 608A
20 using an appropriate communication channel 630 such as a modem communications path, an electronic network, or the like. The network may include a local area network (LAN), a wide area network (WAN), an Intranet, and/or the Internet.

The computer 602 includes: a central processing unit(s) (simply referred to as a
25 processor hereinafter) 604, a memory 606 that may include random access memory (RAM) and read-only memory (ROM), input/output (IO) interfaces 608A and 608B, a video interface 610, and one or more storage devices generally represented by a block 612 in Fig. 6. The storage device(s) 612 can consist of one or more of the following: a floppy disc, a hard disc drive, a magneto-optical disc drive, CD-ROM, magnetic
30 tape or any other of a number of non-volatile storage devices well known to those skilled in the art.

Preferably, the system 600 also includes a MIDI interface 640, which can connect to an external synthesiser (not shown). More preferably, the system 600 can include a sound card 640, which may also implement the MIDI interface. The sound card 640 can capture and/or reproduce audio signals and may incorporate a built-in synthesiser (e.g. a wavetable synthesiser).

Each of the components 604 to 612 and 640 is typically connected to one or more of the other devices via a bus 614 that in turn can consist of data, address, and control buses. Numerous other devices can be employed as part of the computer system 600 including a video capture card, for example. The video interface 610 is connected to the video display 616 and provides video signals from the computer 602 for display on the video display 616. User input to operate the computer 602 can be provided by one or more input devices via the interface 608B. For example, an operator can use the keyboard 618 and/or a pointing device such as the mouse 620 to provide input to the computer 602.

The system 600 is simply provided for illustrative purposes and other configurations can be employed without departing from the scope and spirit of the invention. Computers with which the embodiment can be practised include IBM-PC/ATs or compatibles, one of the Macintosh (TM) family of PCs, Sun Sparcstation (TM), a workstation or the like. Many such computers use graphical operating systems such as Microsoft Windows 95 and 98, for example. The foregoing is merely exemplary of the types of computers with which the embodiments of the invention may be practised. Typically, the processes of the embodiments are resident as software or a program recorded on a hard disk drive (generally depicted as block 612 in Fig. 6) as the computer readable medium, and read and controlled using the processor 604. Intermediate storage of the program and any data fetched from the network may be accomplished using the semiconductor memory 606, possibly in concert with the hard disk drive 612.

In some instances, the program may be supplied to the user encoded on a CD-ROM or a floppy disk (both generally depicted by block 612), or alternatively could be read by

the user from the network via a modem device connected to the computer, for example. Still further, the computer system 600 can load the software from other computer readable medium. This may include magnetic tape, a ROM or integrated circuit, a magneto-optical disk, a radio or infra-red transmission channel between the
5 computer and another device, a computer readable card such as a PCMCIA card, and the Internet and Intranets including email transmissions and information recorded on web sites and the like. The foregoing is merely exemplary of relevant computer readable mediums. Other computer readable mediums may be practised without departing from the scope and spirit of the invention.

10

A system for embedding watermark data into a WT audio file; and extracting watermark data from an embedding WT audio file is referred to KentMark (WT).

15

In the foregoing manner, a method, an apparatus, and a computer program product for digital audio watermarking of wavetable (WT) audio are disclosed. Correspondingly, a method, an apparatus, and a computer program product for extracting digital audio watermarks from watermarked WT audio are disclosed. While only a small number of embodiments are described, it will be apparent to those skilled in the art in view of this disclosure that numerous changes and/or modifications can be made without

20

departing from the scope and spirit of the invention.

Appendix A

5 Redundancy Low-Bit Coding Based on FA and HAS

The basic idea in low-bit coding is to embed a watermark into an audio signal by replacing the least significant bit of each sampling point by a coded binary string corresponding to the watermark. For example, in a 16-bits per sample representation, the least four bits can be used for hiding the watermark. The hidden data detection in
10 low-bit coding is done by reading out the value from the low bits. The stego key is the position of the altered bits. Low-bit coding a simple way to embed data into digital audio and can be applied in all ranges of transmission rates with digital communication modes. Preferably, the channel capacity can be 8kbps in an 8kHz sampled sequence and 44kps in a 44kHs sampled sequence for a noiseless channel
15 application.

An example procedure of redundancy low-bit coding method based on a finite automation (FA) and HAS is:

- 20 (1) Convert the watermark message into a binary sequence;
- (2) Determine the values of the elements in the FA, that is, the number of sample points that are jumped off corresponding relevant states:
 y_1 : state 00
 y_2 : state 01
25 y_3 : state 10
 y_4 : state 11
- (3) Determine the redundant number for 0 and 1 bit to be embedded:
 r_0 : the embedded number for 0 bit; and
 r_1 : the embedded number for 1 bit.
- 30 (4) Determine the HAS threshold T ;
- (5) For each bit of the binary sequence corresponding to watermark message and the sample point in the WT sample data:

- (a) Compare the amplitude value A of the sample point with the HAS threshold T , if $A < T$ then goto next point, else
- (b) Step over y_i ($i = 1, 2, 3, 4,$) number of points and replace the lowest bit of r_j ($j = 0, 1$) number of points by the bit of the binary sequence;
- (c) Repeat until all bits in binary sequence are processed.

Appendix B

The basic idea in parameters hiding is to embed the watermark information into the articulation parameters of WT audio by generating virtual parameters. To illustrate this, Downloadable Sounds (DLS) Level 1 are considered as the WT audio to show how to hide watermark information in the articulation parameters.

The following steps are performed:

- (1) Encrypt the watermark binary sequence and watermarked low-bits sequence;
- (2) Segment the encrypted data stream into n parts;
- 10 (3) Create a virtual instrument in the DLS file, and use its parameters to hide the watermark information.

The virtual instrument collection to hide watermark information can be described as follows:

15

LIST 'ins'

LIST 'INFO'

Inam "Instrument name"

<dlid> (watermark Info part 1)

20

<insh> (watermark Info part 2)

LIST 'Irgn'

LIST 'rgn'

<rgnh> (watermark Info part 3)

<wsmp> (watermark Info part 4)

25

<wlnk> (watermark Info part 5)

LIST 'rgn'

.

.

.

30

...

LIST 'lart'

<art1> (watermark Info part n)

Claims:

1. A method of embedding a digital watermark in digital audio data coded using a synthesiser-architecture format, said method including the steps of:
5 embedding at least a portion of said digital watermark in sample data and articulation parameters of said synthesiser-architecture format.
2. The method according to claim 1, further including the step of adaptively coding said digital watermark in said sample data.
10
3. The method according to claim 2, wherein redundancy adaptive coding is used based on a finite automaton.
4. The method according to claim 1, further including the step of hiding
15 said digital watermark in said articulation parameters by creating virtual parameters.
5. The method according to claim 4, further including the step of embedding said digital watermark in said virtual parameters.
- 20 6. The method according to claim 4 or 5, further including the step of extracting one or more coded bits from watermarked sample data, said virtual parameters created dependent upon a watermarked coded bit sequence.
7. The method according to claim 6, further including the step of hiding
25 said watermarked coded bit sequence in said articulation parameters.
8. The method according to claim 7, further including the step of embedding said watermarked coded bit sequence in said virtual parameters.
- 30 9. The method according to claim 7 or 8, further including the step of encrypting said digital watermarked coded bit sequence.

10. The method according to claim 4 or 5, further including the step of encrypting said digital watermark.

11. The method according to any one of claims 1 to 10, further including
5 the step of generating said digital watermark.

12. The method according to any one of claims 1 to 11, further including
the step of dividing said digital audio data coded using a synthesiser-architecture
format into said sample data and said articulation parameters.
10

13. The method according to any one of claims 1 to 12, further including
the step of embedding a playback-control signal.

14. The method according to any one of claims 1 to 13, wherein said
15 digital audio data coded using a synthesiser-architecture format is wavetable (WT)
audio.

15. An apparatus for embedding a digital watermark in digital audio data
coded using a synthesiser-architecture format, said apparatus including:
20 means for embedding at least a portion of said digital watermark in sample
data of said synthesiser-architecture format; and
means for embedding at least a portion of said digital watermark in
articulation parameters of said synthesiser-architecture format.

25 16. The apparatus according to claim 15, further including means for
adaptively coding said digital watermark in said sample data.

17. The apparatus according to claim 16, wherein redundancy adaptive
coding is used based on a finite automaton.
30

18. The apparatus according to claim 15, further including means for hiding said digital watermark in said articulation parameters by creating virtual parameters.

5 19. The apparatus according to claim 18, further including means for embedding said digital watermark in said virtual parameters.

20. The apparatus according to claim 18 or 19, further including means for extracting one or more coded bits from watermarked sample data, said virtual
10 parameters created dependent upon a watermarked coded bit sequence.

21. The apparatus according to claim 20, further including means for hiding said watermarked coded bit sequence in said articulation parameters.

15 22. The apparatus according to claim 21, further including means for embedding said watermarked coded bit sequence in said virtual parameters.

23. The apparatus according to claim 21 or 22, further including means for encrypting said digital watermarked coded bit sequence.

20 24. The apparatus according to claim 18 or 19, further including means for encrypting said digital watermark.

25 25. The apparatus according to any one of claims 15 to 24, further including means for generating said digital watermark.

26. The apparatus according to any one of claims 15 to 25, further including means for dividing said digital audio data coded using a synthesiser-architecture format into said sample data and said articulation parameters.

30 27. The apparatus according to any one of claims 15 to 26, further including means for embedding a playback-control signal.

28. The apparatus according to any one of claims 15 to 27, wherein said digital audio data coded using a synthesiser-architecture format is wavetable (WT) audio.

5

29. A computer program product having a computer readable medium having a computer program recorded therein for embedding a digital watermark in digital audio data coded using a synthesiser-architecture format, said computer program product including:

10 means for embedding at least a portion of said digital watermark in sample data of said synthesiser-architecture format; and

means for embedding at least a portion of said digital watermark in articulation parameters of said synthesiser-architecture format.

15

30. The computer program product according to claim 29, further including means for adaptive coding said digital watermark in said sample data.

31. The computer program product according to claim 30, wherein said redundancy adaptive coding is used based on a finite automaton.

20

32. The computer program product according to claim 29, further including means for hiding said digital watermark in said articulation parameters by creating virtual parameters.

25

33. The computer program product according to claim 32, further including means for embedding said digital watermark in said virtual parameters.

30

34. The computer program product according to claim 32 or 33, further including means for extracting one or more coded bits from watermarked sample data, said virtual parameters created dependent upon a watermarked coded bit sequence.

35. The computer program product according to claim 34, further including means for hiding said watermarked coded bit sequence in said articulation parameters.

5 36. The computer program product according to claim 35, further including means for embedding said watermarked coded bit sequence in said virtual parameters.

37. The computer program product according to claim 35 or 36, further
10 including means for encrypting said digital watermarked coded bit sequence.

38. The computer program product according to claim 32 or 33, further including means for encrypting said digital watermark.

15 39. The computer program product according to any one of claims 29 to 38, further including means for generating said digital watermark.

40. The computer program product according to any one of claims 29 to 39, further including means for dividing said digital audio data coded using a
20 synthesiser-architecture format into said sample data and said articulation parameters.

41. The computer program product according to any one of claims 29 to 40, further including means for embedding a playback-control signal.

25 42. The computer program product according to any one of claims 29 to 41, wherein said digital audio data coded using a synthesiser-architecture format is wavetable (WT) audio.

43. A method of extracting a digital watermark from watermarked digital audio data coded using a synthesiser-architecture format, said method including the steps of:

5 detecting a watermark from articulation parameters of said watermarked digital audio data coded using a synthesiser-architecture format;
detecting a watermark from sample data of said watermarked digital audio data coded using a synthesiser-architecture format; and
10 verifying said watermark by comparing said detected watermarks.

44. The method according to claim 43, further including the step of replacing the watermark from said sample data with a corresponding watermark embedded in said articulation parameters if said watermark from said sample data is
15 not available or has been modified.

45. The method according to claim 43 or 44, wherein said watermark from sample data includes an adaptively coded bit sequence.

20 46. The method according to claim 45, further including the step of decrypting said adaptively coded bit sequence.

47. The method according to claim 43 or 46, further including the step of decrypting said digital watermark.

25 48. The method according to any one of claims 43 to 47, further including the step of dividing said watermarked digital audio data coded using a synthesiser-architecture format into said sample data and said articulation parameters.

30 49. The method according to any one of claims 43 to 48, further including the step of extracting a playback-control signal.

50. The method according to any one of claims 43 to 49, wherein said digital audio data coded using a synthesiser-architecture is wavetable (WT) audio.

51. An apparatus for extracting a digital watermark from watermarked
5 digital audio data coded using a synthesiser-architecture format, said apparatus including:

means for detecting a watermark from articulation parameters of said watermarked digital audio data coded using a synthesiser-architecture format;

10 means for detecting a watermark from sample data of said watermarked digital audio data coded using a synthesiser-architecture format; and

means for verifying said watermark by comparing said detected watermarks.

52. The apparatus according to claim 51, further including means for replacing the watermark from said sample data with a corresponding watermark
15 embedded in said articulation parameters if said watermark from said sample data is not available or has been modified.

53. The apparatus according to claim 51 or 52, wherein said watermark from sample data includes an adaptively coded bit sequence.
20

54. The apparatus according to claim 53, further including means for decrypting said adaptively coded bit sequence.

55. The apparatus according to claim 51 or 54, further including means for
25 decrypting said digital watermark.

56. The apparatus according to any one of claims 51 to 55, further including means for dividing said watermarked digital audio data coded using a synthesiser-architecture format into said sample data and said articulation parameters.
30

57. The apparatus according to any one of claims 51 to 56, further including means for extracting a playback-control signal.

58. The apparatus according to any one of claims 51 to 57, wherein said digital audio data coded using a synthesiser-architecture format is wavetable (WT) audio.

5

59. A computer program product for extracting a digital watermark from watermarked digital audio data coded using a synthesiser-architecture format, said computer program product including:

- means for detecting a watermark from articulation parameters of said
- 10 watermarked digital audio data coded using a synthesiser-architecture format;
- means for detecting a watermark from sample data of said watermarked digital audio data coded using a synthesiser-architecture format; and
- means for verifying said watermark by comparing said detected watermarks.

15 60. The computer program product according to claim 59, further including means for replacing the watermark from said sample data with a corresponding watermark embedded in said articulation parameters if said watermark from said sample data is not available or has been modified.

20 61. The computer program product according to claim 59 or 60, wherein said watermark from sample data includes an adaptively coded bit sequence.

62. The computer program product according to claim 61, further including means for decrypting said adaptively coded bit sequence.

25

63. The computer program product according to claim 59 or 62, further including means for decrypting said digital watermark.

64. The computer program product according to any one of claims 59 to
30 63, further including means for dividing said watermarked digital audio data coded using a synthesiser-architecture format into said sample data and said articulation parameters.

65. The computer program product according to any one of claims 59 to 64, further including means for extracting a playback-control signal.

5 66. The computer program product according to any one of claims 59 to 65, wherein said digital audio data coded using a synthesiser-architecture is wavetable (WT) audio.

 67. A system for watermarking a wavetable (WT) audio file, said system
10 including:
 means for embedding watermark data into a WT file; and
 means for extracting said watermark data from said embedded WT file.

 68. A method of playing a watermarked wavetable (WT) audio file having
15 a control signal embedded therein to control the number of playbacks, said method including the steps of:

 automatically checking the watermarked WT file for said control signal to ensure authentication;
 if said control signal indicates at least one playback remains, playing said
20 watermarked WT file; and
 decrementing said control signal.

Method and Apparatus for Watermarking Wavetable Synthesis Architectures**Abstract**

- 5 A method, an apparatus, and a computer program product for digital audio watermarking of wavetable (WT) format audio, including downloadable sounds (DLS) (110), are disclosed. Correspondingly, a method, an apparatus, and a computer program product for extracting watermarks (126, 552) from a digital audio watermarked WT audio (162, 510) are disclosed. In particular, a digital audio
- 10 watermark (126) is embedded (140, 130) in both articulation parameters (122) and sample data (124) of a DLS (110). A finite automaton module (220) is used to implement adaptive coding (130) of the sample data (124). Virtual parameters (430) are generated for information hiding (140) applied to the articulation parameters (122). Optionally, playback of the WT (152) can be limited by an embedded control
- 15 signal. Brief overviews of MIDI and DLS are provided.

Fig. 1

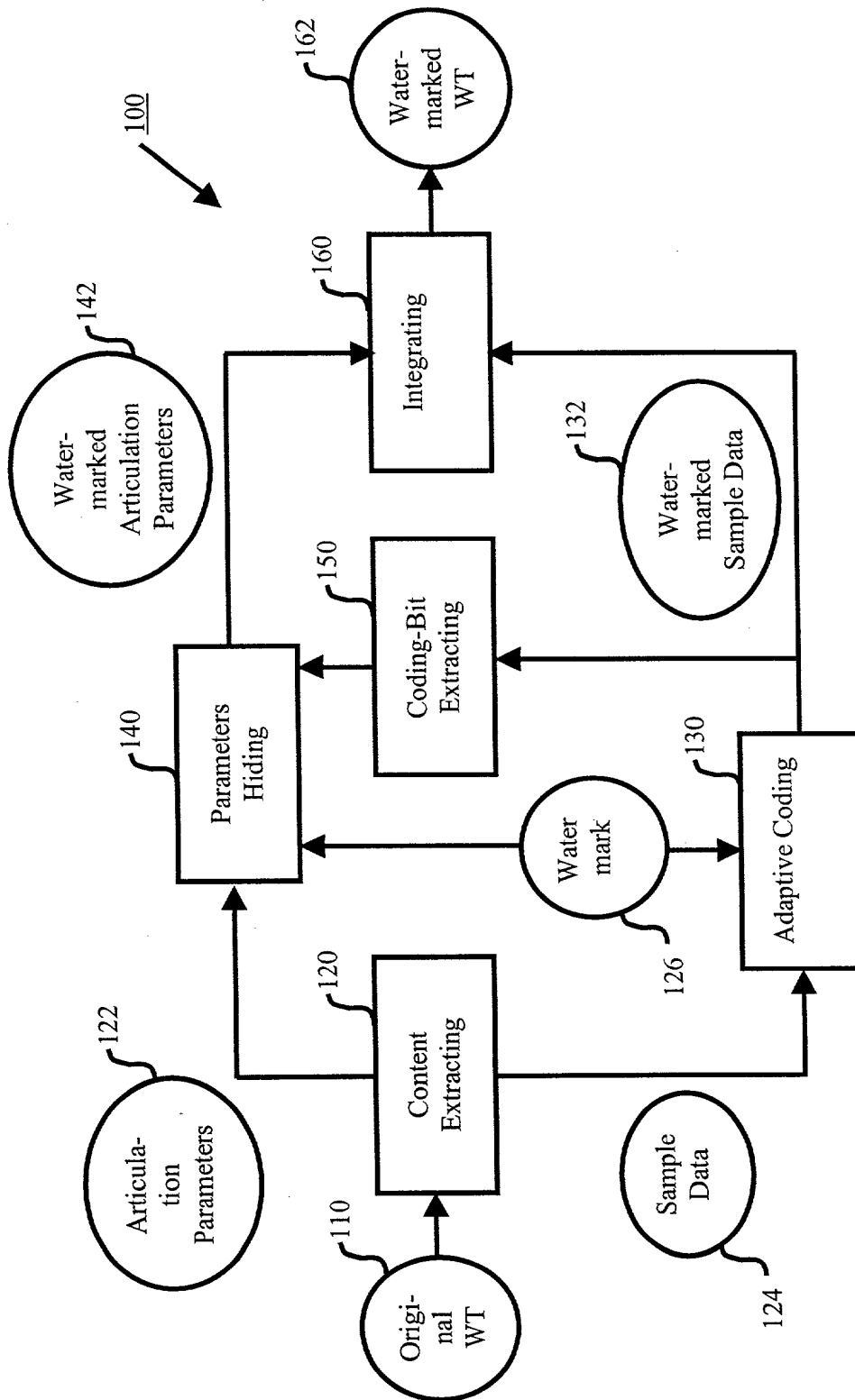


FIG. 1

-2/6-

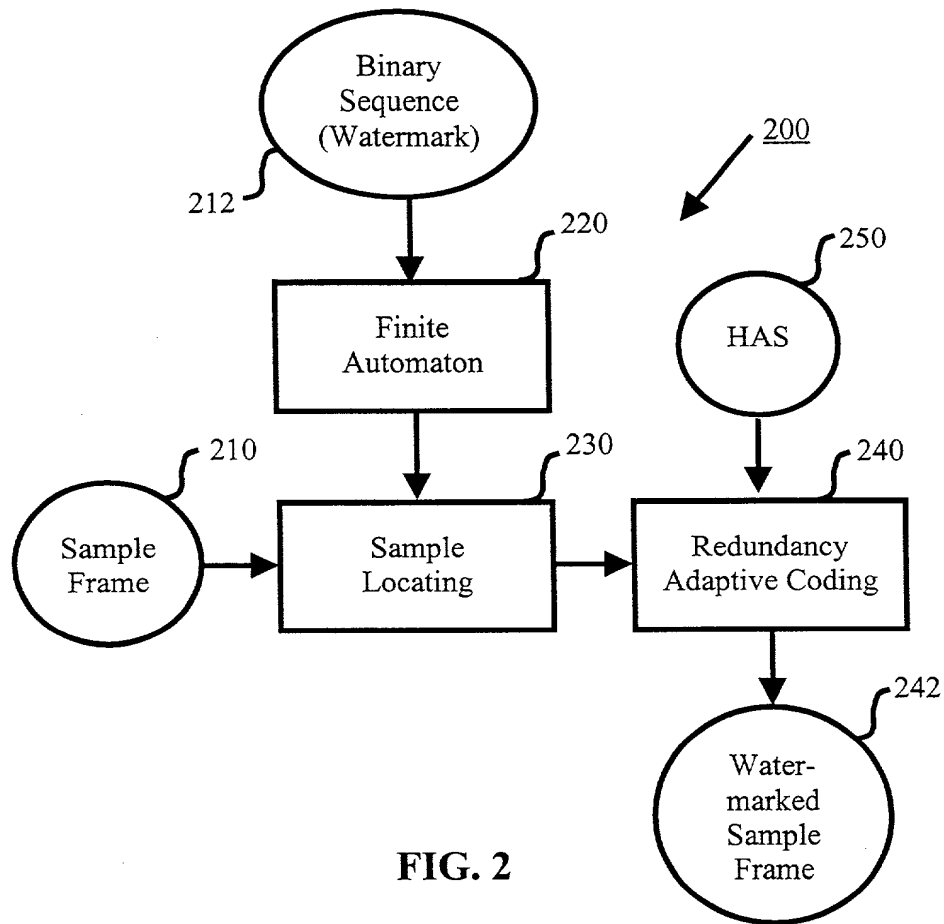


FIG. 2

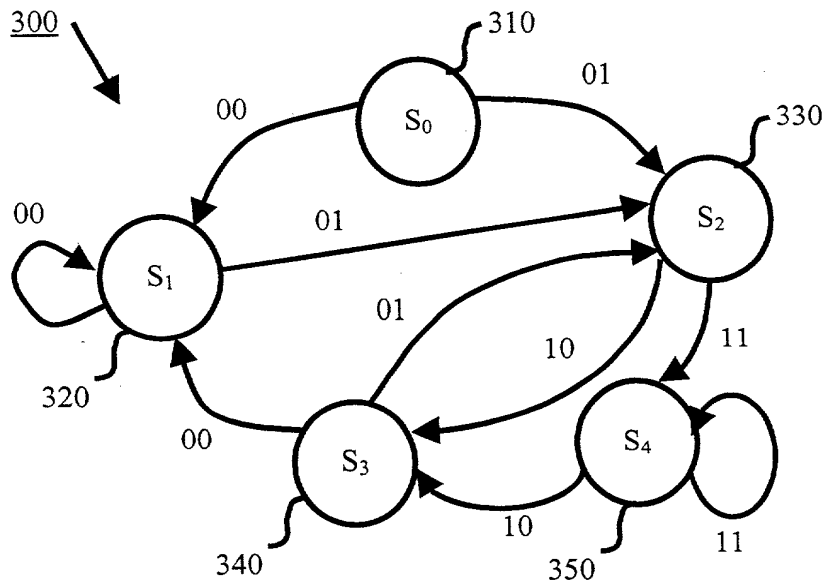


FIG. 3

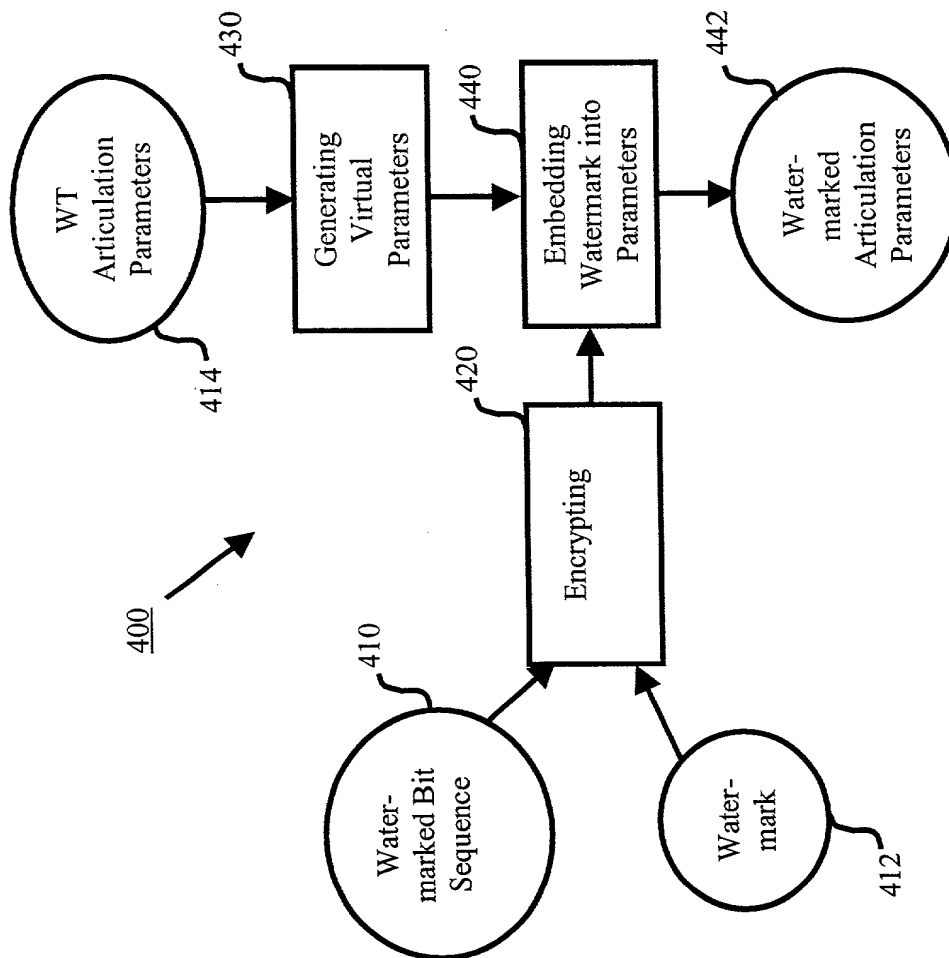


FIG. 4

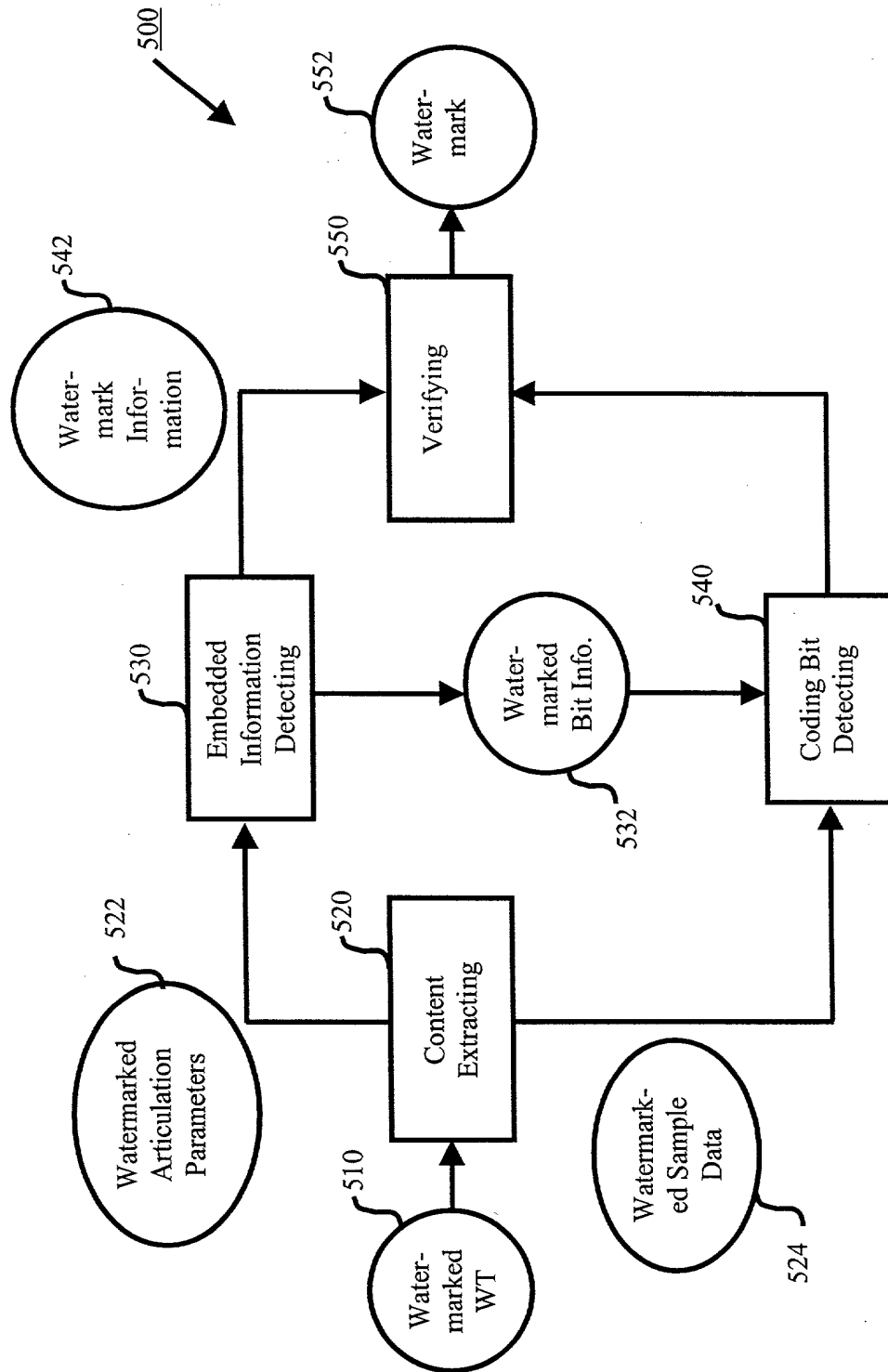


FIG. 5

-5/6-

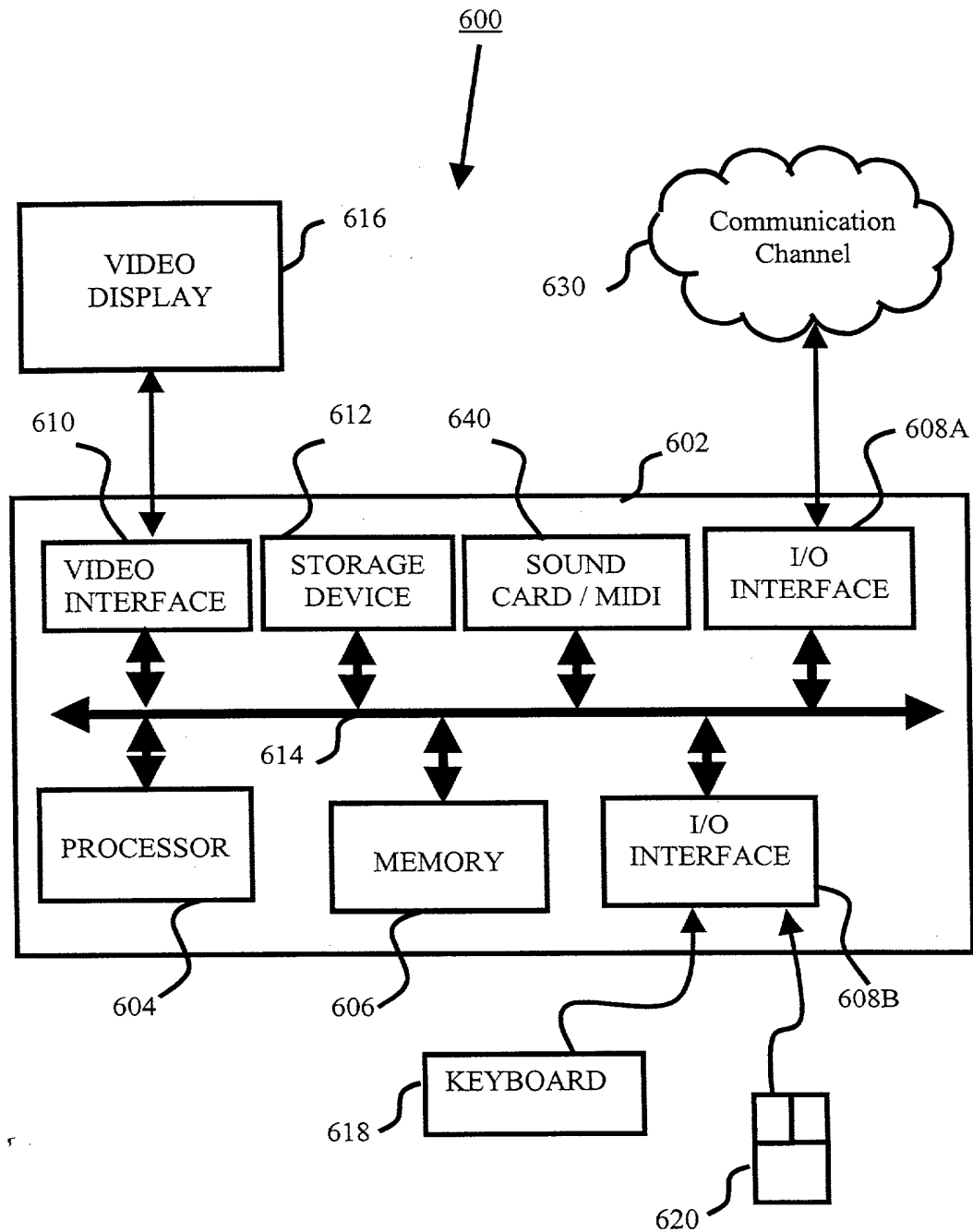


FIG. 6

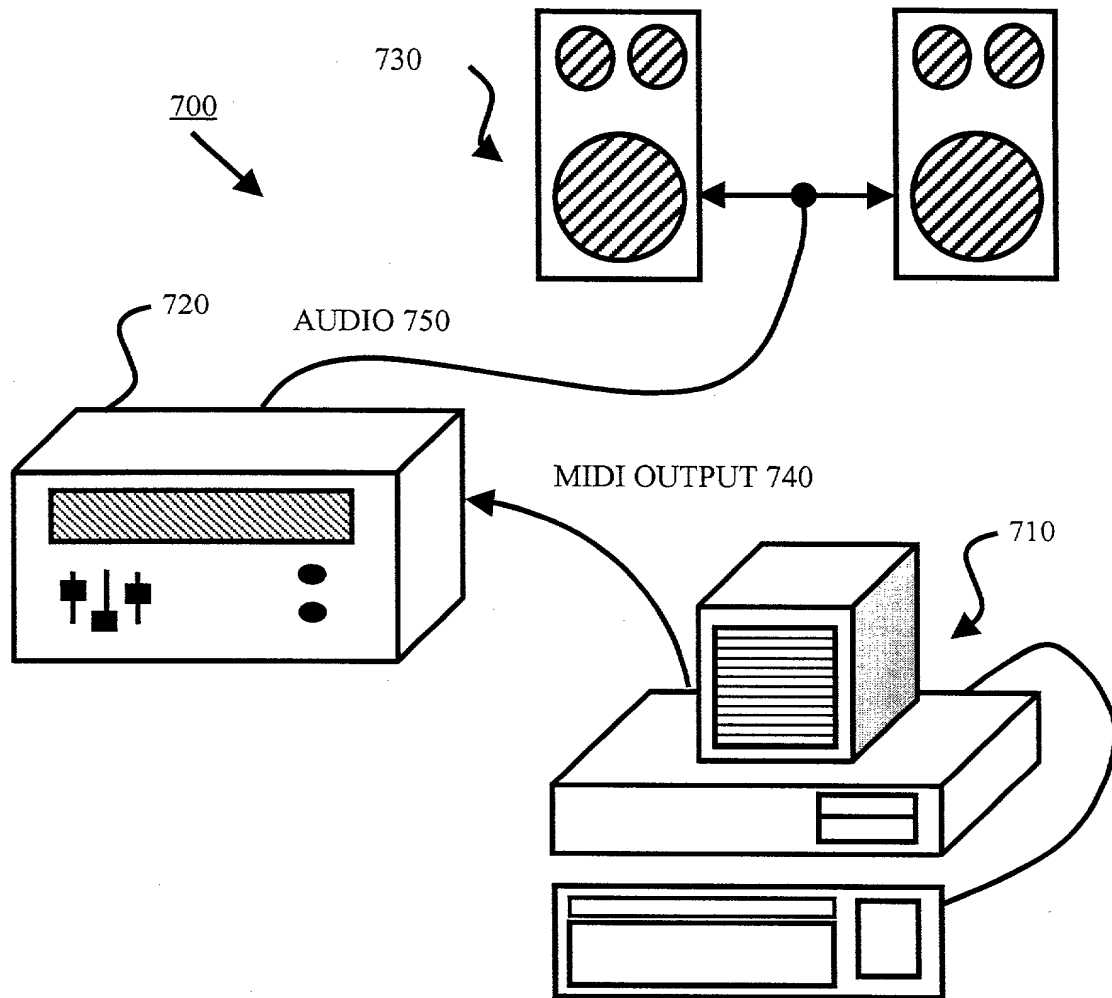


FIG. 7

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

Attorney Docket Number

First Named Inventor

XU, Changsheng

COMPLETE IF KNOWN

Application Number

/

Filing Date

Group Art Unit

Examiner Name

☒ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method And Apparatus For Watermarking Wavetable Synthesis Architectures

the specification of which

(Title of the Invention)

☐ is attached hereto

OR

☒ was filed on (MM/DD/YYYY) 01/28/1999

as United States Application Number or PCT International

Application Number PCT/SG99/00004 and was amended on (MM/DD/YYYY) (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
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			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

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[Page 1 of 2]

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U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (If applicable)
PCT/SG99/00004	01/28/1999	

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle (if any))	Family Name or Surname
Changsheng	Xu

Inventor's Signature				Date	06/04/99
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Post Office Address	Blk 702, West Coast Road, #13-345 #06-337				
Post Office Address	Republic of Singapore				
City	Singapore	State		ZIP	120702
Country	Singapore				

☒ Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto



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ADDITIONAL INVENTOR(S)
 Supplemental Sheet
 Page 1 of 1

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Given Name (first and middle [if any])				Family Name or Surname			
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Post Office Address	Republic of Singapore						
City	Singapore	State		ZIP	600051	Country	Singapore
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
Given Name (first and middle [if any])				Family Name or Surname			
Qibin				Sun			
Inventor's Signature						Date	10/3/99
Residence: City	Singapore	State		Country	Singapore	Citizenship	Chinese SGX
Post Office Address	Blk 407, Clementi Avenue 1, #11-54						
Post Office Address	Republic of Singapore						
City	Singapore	State		ZIP	120407	Country	Singapore
Name of Additional Joint Inventor, if any:				<input type="checkbox"/> A petition has been filed for this unsigned inventor			
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Inventor's Signature						Date	
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Post Office Address							
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Filing Date	
First Named Inventor	XU, Changsheng
Group Art Unit	
Examiner Name	
Attorney Docket Number	

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JOHN RICHARDS	31053
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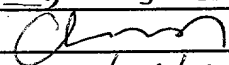
<input checked="" type="checkbox"/> Firm or Individual Name	LADAS & PARRY				
Address	26 WEST 61ST STREET				
Address					
City	NEW YORK	State	NY	ZIP	10023
Country	UNITED STATES OF AMERICA				
Telephone	(212) 708-1800	Fax	(212) 246-8959		

I am the:

☒ Applicant.

☐ Assignee of record of the entire interest
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SIGNATURE of Applicant or Assignee of Record

Name	XU, Changsheng
Signature	
Date	06/04/1999

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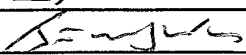
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